INDUSTRIAL SANDS OF THE INDIANA DUNES

by

C. L. BIEBER AND NED M. SMITH

Indiana Department of Conservation
GEOLOGICAL SURVEY
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INDUSTRIAL SANDS OF THE INDIANA DUNES

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ABSTRACT

Upon retreat of the Pleistocene ice north of the Valparaiso and associated moraines, the damming of north-flowing drainage resulted in the formation of Lake Chicago. This lake passed through at least four phases of water levels before it became the present Lake Michigan. Beaches which were formed during several phases of Lake Chicago and Lake Michigan are sources of commercial sand.

The commercial operations which remove sand from these deposits have been examined. Industrial sand deposits south of Lake Michigan are shown in Plate 1. Sand samples were taken for laboratory determination of sieve sizes, density separation, and chemical analysis. Composition and roundness of sand grains, as well as details of bedding, weathering, porosity, bonding, and moisture content, were studied.

The general requirements for each of the uses made of dune sand are summarized. Although it is used extensively for molding sand for some types of large castings, the greatest quantity has been used as fill sand, and smaller amounts have been utilized for asphalt paving sand, core sand, fire and furnace sand, engine sand, and glass sand. To produce economically the required sand for industry, cranes and railroad cars are necessary. Some foundry operators dry the sand in order to control moisture more effectively.

To ensure a steady supply, sand dunes should be large enough and sidings long enough to accommodate several cars at one time. Space must be allowed for the free movement of a crane from car to car. As winter weather may curtail sand operations, the operators must plan their work ahead in order to meet schedules.

The removal of the sand does not leave the land waste. The operators can readily divide the land into residential subdivisions and thus gain additional revenue. Natural dunes are preserved in the Indiana Dunes State Park and in some residential areas.

If the present supply and demand is maintained, 50 to 100 years of sand operations are possible.

INTRODUCTION

The purpose of this paper is to outline the extent of the present commercial sand operations in northwestern Indiana in the immediate vicinity of Lake Michigan, to describe the sands available, and to indicate the extent of past operations (Pl. 1). Regional geology and production practices are discussed briefly.

The most extensive commercial sand operations are in Porter and LaPorte Counties and eastern Lake County. All are within

3 miles of Lake Michigan. Ten large sand pits and several smaller ones were in operation in 1950.

Commercial use of sand in this area is related to the expansion of the iron and steel industry in the Chicago area since about 1885. The growth both of iron and steel mills in northern Lake County since World War I and of the many foundries and factories attracted to the area has increased rapidly the demand for sand. The prosperity of the sand industry has fluctuated with the demand for finished metals.

ACKNOWLEDGMENTS

This investigation was made at the request of the State Geologist, Dr. Charles F. Deiss. The writers express appreciation to John B. Patton and the staff of the Industrial Minerals Section of the Geological Survey, Indiana Department of Conservation, for helpful supervision and for processing samples. Russell Manley of the Manley Sand Company and Carter Many of Michigan City were especially helpful in giving information and in assisting in the field work. George and Joseph Nicholson gave valuable aid in the study of the Crisman area sands. Cooperation of cranemen Carl Helsing, Ted Jensen, and Harry Larson made possible the study and sampling of the sand pits. William Freyer of Weil-McLain Company and H. Klouman of Michiana Products Corporation, both of Michigan City, offered pertinent information on molding sands.

GEOLOGY

LATE PLEISTOCENE HISTORY

General statement.—All the commercial sand pits are associated with the shore lines of Lake Michigan or with the beaches and dunes of ancient glacial Lake Chicago (Pl. 1). These sands of lacustrine-eolian origin commonly are referred to as "dune" or "lake" sand. A description (Leverett, 1899, pp. 418-453) of the location of the beaches is briefly summarized here.

Upon retreat of the Pleistocene ice after deposition of the Valparaiso morainic system (Leverett, 1899, p. 339) and the Tinley moraine (Leighton and Ekblaw, 1933, p. 15) which lies against the northern flanks of the Valparaiso moraine, a lake was formed between the moraines and the retreating ice. The lake, although

relatively small, accounted for lake silts and sand which are found in LaPorte County between the Covert Ridge of the Lake Border morainic system (Leverett and Taylor, 1915, p. 321) and the Valparaiso morainic system (Pl. 1), and which are found westward along the flanks of the moraines in Porter and Lake Counties. Drainage from the overflowing lake spilled southward through gaps in the moraines, especially the gaps in the vicinity of Woodville and Salt Creek.

Glenwood phase, Lake Chicago.—As the basin which now is occupied by Lake Michigan was partially freed of ice by the melting that accompanied the shrinking ice caps, the meltwater filled the south end of the basin and overflowed through the Sag channel and DesPlaines River. The lake, thus established, Leverett (1897, p. 65) called Lake Chicago. The water level was approximately 55 to 60 feet above the present level of Lake Michigan. The overflow spilled through the southwestern outlet ultimately to the Gulf of Mexico.

The highest level of Lake Chicago formed what Leverett (1897, p. 66) called the Glenwood beach. Subsequent lower levels also formed recognizable beaches and associated phenomena.[1] The Glenwood level persisted for many years dammed behind the Tinley moraine and outwash train (Bretz, 1951, p. 410). The Glenwood beach is rendered indistinct by the many embayments along the moraines. However, between Schererville and Dyer in western Lake County, and from west of Furnessville in Porter County northeastward into Michigan, the beach is discernible. Several pits have been excavated in coarse sand and beach gravel in the Glenwood beach between Furnessville and Michigan City (Pl. 1). Because sand deposits generally are of limited quantity along the Glenwood beach, this beach does not contain large commercial pits.

Near the close of the Glenwood phase, advancing ice lobes in the Huron and Erie Basins caused lakes there to spill over into

---

[1] Leverett (1897, pp. 66, 72, 74-75) and later authors referred to the time when these levels were maintained as "stages" of Lake Chicago, or of later glacial lakes and Lake Michigan. Because "stage" has been defined to cover a larger stratigraphic interval and a wider geographic area, its usage in association with lakes in the Great Lakes Basin will not be continued here. The phenomena associated with maintained levels of lakes are merely transitory events; therefore, the words level, beach, or phase are used to achieve the desired meaning with additional refinement.

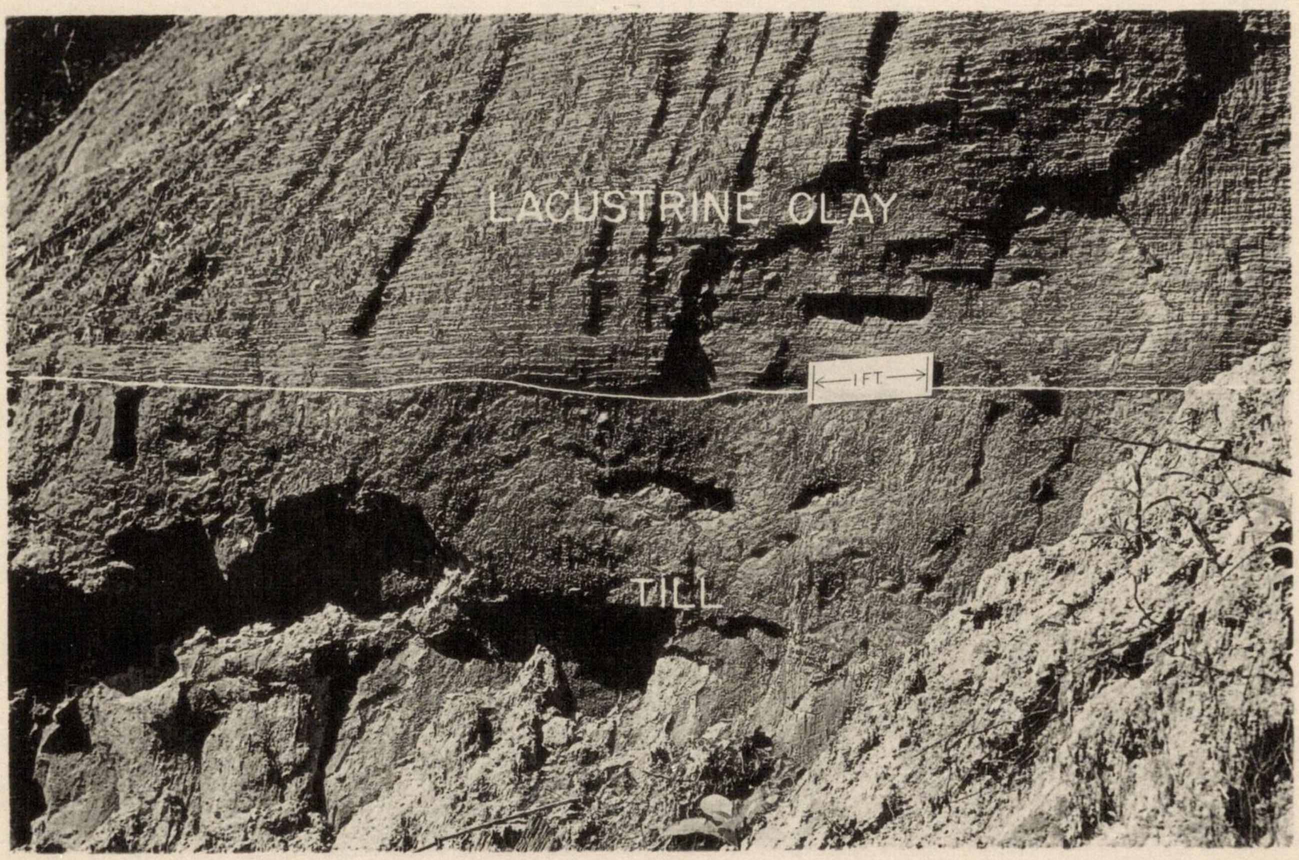
Lake Chicago. The greatly increased water volume cut down the southwestern outlet over the Tinley moraine and dropped the level of Lake Chicago (Bretz, 1951, p. 410).

A low-water phase called Bowmanville by Baker (1910, p. 715) followed the Glenwood phase. Clays exposed along the present lake shore 1 to 2 miles southwest of Michigan City have been ascribed to the Bowmanville (Pl. 2, A). Field examination, however, fails to prove that the clay is of Bowmanville age. These clays contain marl and peat and apparently were deposited in shallow water marshes. Similar clays lie beneath the sand in the vicinity of Crisman (Pl. 2, B). No satisfactory explanation for the drop of the Glenwood level nearly to the present lake level has been set forth (Alden, 1918, p. 331). Ice retreat and a low outlet northeastward (as yet undiscovered) may account for the great drop in the lake level, if indeed such a drop occurred.

Calumet phase, Lake Chicago.—Following the Bowmanville low-water phase, assuming that it existed, slowly advancing lake levels stabilized 35 to 40 feet above the present level of Lake Michigan. The opening of an eastern outlet for lakes in the Erie and Huron Basins probably accounted for a decreased volume of water draining through the southwestern outlet and thus for the preservation of the lowered Tinley boulder dam (Bretz, 1951, p. 411). The new levels remained for sufficient length of time to form a well-defined beach north of the Glenwood line. Embayments were few save for the shallow flats near Griffith, in Lake County, where bars and spits were formed. Sand deposition was greatest at the head of the lake, and here dunes developed on shore. The sand deposits which were produced at this level have been named the Calumet beach (Leverett, 1897, p. 72).

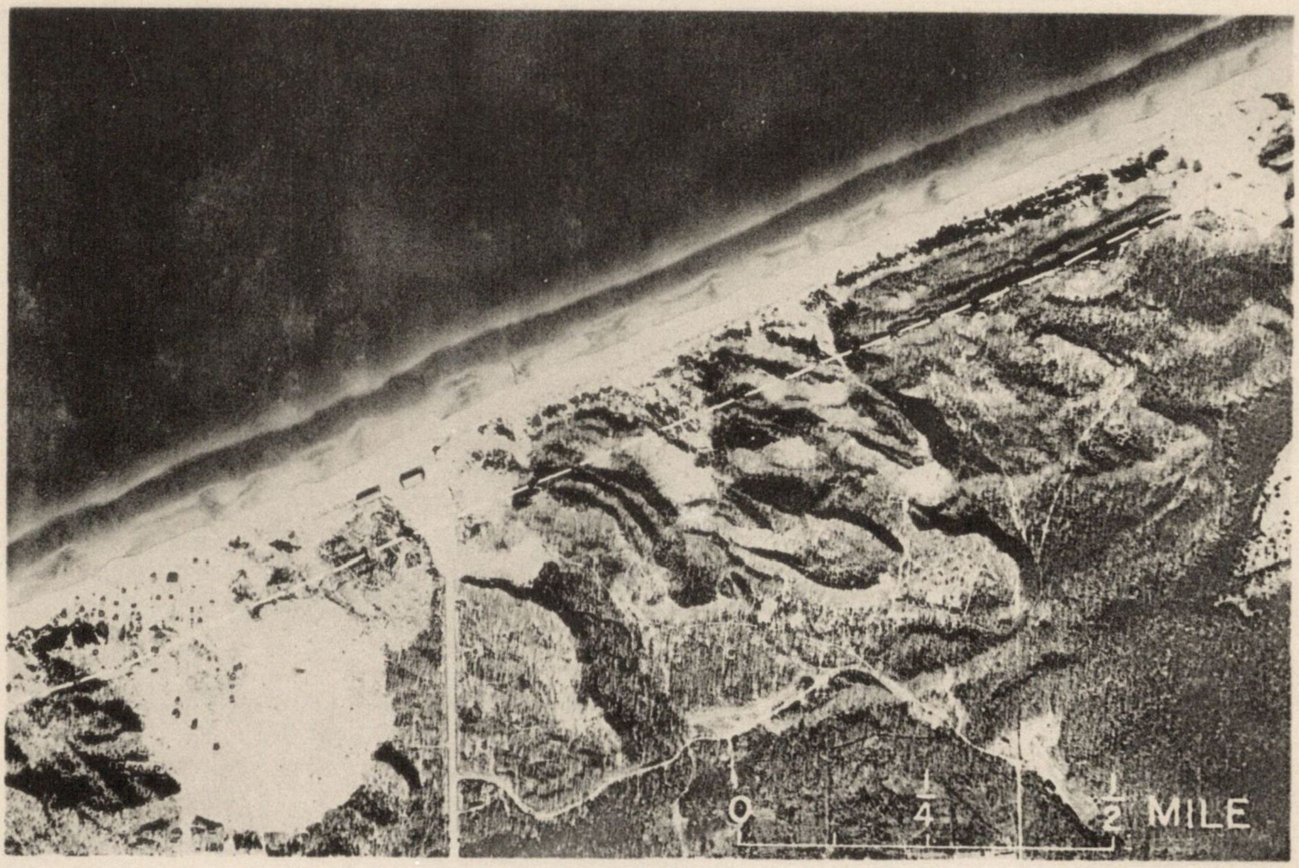
The largest discovered deposits of sand of the Calumet phase are near Willow Creek and Crisman in Porter County (Pl. 1), where pits have been worked for more than 60 years. The following sequence of events may account for these unusual sand deposits: (1) Shore currents of Lake Chicago that moved southward on both sides of the lake reworked and deposited sand at the head of the lake. (2) Salt Creek and Little Calumet River, which entered Lake Chicago near the present junction of the two streams, and Willow Creek carried sand from the Valparaiso morainic system and Glenwood beach to Lake Chicago, where the sand was washed westward along the newly formed Calumet beach. (3) Strong northerly winds blew the beach sands inland

A. CLAY, AT MAN'S FEET, FOREGROUND, 2 MILES SOUTHWEST OF MICHIGAN CITY, NW¼NE¼ SEC. 36, T. 38 N., R. 5 W., PORTER COUNTY.

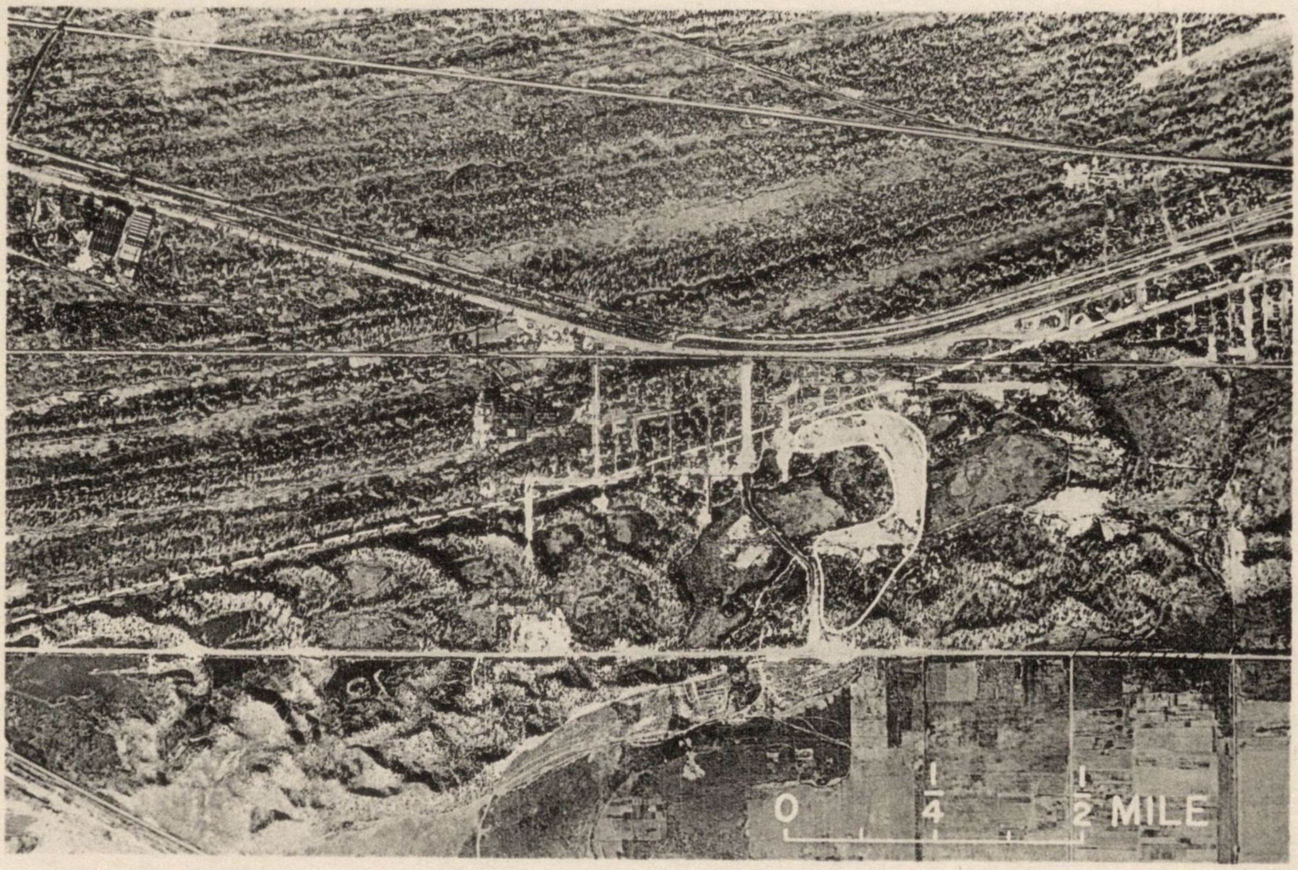


B. LACUSTRINE CLAY OVER TILL (SCALE IS ON CONTACT) ALONG SALT CREEK, 1½ MILES NORTHEAST OF CRISMAN, NW¼NE¼ SEC. 6, T. 36 N., R. 6 W., PORTER COUNTY.

MATERIALS BENEATH THE SAND.



A. PARABOLIC DUNES AND BLOW-OUTS OVERRUNNING TOLLESTON BEACH, INDIANA DUNES STATE PARK. LENGTH OF SHORE LINE APPROXIMATELY 3 MILES.



B. TOLLESTON DUNES BELOW AND BEACHES OF RETREATING POST-TOLLESTON LAKE ABOVE DASHED LINE. OUTLINE SHOWS AREA OF MINED SAND. AREA EAST OF GARY (AETNA), SEC. 12, T. 36 N., R. 8 W., LAKE COUNTY.

SHORE LINES AND DUNE SHAPES.

1 mile or more to form the north-south pattern of parallel sand ridges. (4) Southwesterly winds modified the ridged dunes from time to time.

When the water levels fell slightly in later Calumet time, a conspicuous beach was formed 2 miles north of Griffith across the marshy lagoonal flats north of the Griffith spits and bars (Pl. 1). At the close of the Calumet phase, because the outlets in the Erie and Huron Basins were dammed by ice, water again spilled into Lake Chicago (Bretz, 1951, p. 411). Increased erosion cut the southwestern outlet to bedrock, at which level the next phase began.

Tolleston phase, Lake Chicago.—Levels of Lake Chicago stabilized at about 20 feet above present levels of Lake Michigan to form the Tolleston beach, named for an early settlement near Tenth Avenue and Garfield Street in Gary (Leverett, 1897, p. 74). The beach begins about half a mile south of the above location. In western Lake County, parallel ridges of beach sand marking the diminishing levels are evidence that the Tolleston beach apparently migrated slowly northward.

The beach ridges of Tolleston age are more complex eastward from Gary, for there increased quantities of sand were deposited and later modified by winds. In western Porter County and eastern Lake County, Tolleston beach ridges lap up against Tolleston dunes, which have been truncated in part by later fluctuating lake levels (Pl. 3, B). The Tolleston beach is obscured in eastern Porter County by dunes from post-Tolleston glacial lakes Nipissing and Algoma. Beach pebbles can be found on the wave-cut bank 15 to 20 feet above the present lake level in the vicinity of the Porter-LaPorte county line, where the beach is being eroded by the present lake (Pl. 3, A).

Lake Chicago disappeared at the close of the Tolleston phase when the Straits of Mackinac had cleared of ice and erosion had sufficiently deepened the Port Huron outlet. Lake Algonquin probably came into existence in the north at this time.

Lake Michigan phase.—After the lake water slowly retreated from the Tolleston shores, present Lake Michigan came into existence. A lake plain that is ridged with nearly parallel sandy beaches which are separated by swampy areas is evidence of the retreat. The sand beach ridges commonly are 30 to 70 feet wide and 3 to 10 feet high. Eastward into Porter County, the ridges

merge into other parallel sand ridges and dunes, 20 to 40 feet high.

A total of 79 sand ridges, as described above, has been counted on the aerial photographs on a line along Colfax Avenue, Lake County, between the Tolleston beach and the present Lake Michigan shore (Pl. 5, B). These sand beach deposits, which probably correlate with the Nipissing and Algoma beaches of Wisconsin and Michigan, are being destroyed by the expansion of industrial plants.

The present Lake Michigan shore line has been more or less stable for some time. Sands derived from weathered glacial drift, Cambrian sandstone, and other quartz-bearing rocks continue to be carried to the head of Lake Michigan by longshore currents. Dunes at a distance of 1 mile or more from shore were built from the beach ridges that were deposited by the retreating lake during Nipissing, Algoma, and later time. The dunes closest to the present shore correlate with phases of present Lake Michigan except where lake erosion in the Michigan City area has cut into dunes of probable Tolleston age. Fluctuation of lake levels, which has averaged more than 3 feet during the last century, changes somewhat the erosion and deposition patterns. In general, however, the greatest accumulation of sand has been eastward from Gary along the lake shore.

AGE OF THE BEACH SAND DEPOSITS

Various estimates have been made to date geological events late in the Pleistocene epoch. According to some students, the retreat of the ice from the great moraines encircling the southern end of the Lake Michigan Basin began about 20,000 years ago. The Glenwood beach, formed some 5,000 to 8,000 years later by Lake Chicago, is a subdued feature. Moreover, the sands are more markedly stained by iron oxides than are the younger beach sands. Likewise, the Calumet beach, although a definite topographic feature, has associated dunes which are not nearly so prominent as the more recent Tolleston and post-Tolleston dunes. Thus quantity, erosion, weathering, color, and leaching indicate the relative age of the beach sands.

Owing to recent studies in the radiocarbon method of dating, estimates of the age of the beach sands have become more accurate. Because of its stratigraphic certainty, a radiocarbon

sample from the Two Creeks peat and "forest" deposit along the Lake Michigan shore in northern Manitowoc County, Wisconsin, can be used as a key. Geologists have considered this deposit as interglacial between Cary and Mankato drift. Glenwood shore features are obscure on the Wisconsin red drift near Two Creeks, Wisconsin (Bretz, 1951, p. 420), but probable Calumet beaches can be distinguished. Thus it follows that the age of the forest bed is post-Glenwood and pre-Calumet and perhaps correlates with the Bowmanville low-water phase.

Several samples of the woody materials were analyzed for content of radioactive carbon 14. The age averages 11,404 years with a possible error of 350 years (Flint and Deevey, 1951, pp. 261-263). The age of a sample of probable early Nipissing (post-Tolleston) peat is 3,656 ± 640 years. From these data the following approximate estimates of age can be made:

Glenwood sand	12,000-14,000 years
Calumet sand	9,000-12,000 years
Tolleston sand	5,000- 9,000 years
Beach ridges of the Lake Michigan Plain (including Nipissing)	? - 5,000 years

As radiocarbon analysis, pollen analysis, and other methods of dating are improved, refinements in these estimates will be possible.

Leverett (1899, pp. 455-459) estimated the age of Lake Michigan as 3,000 years by (1) dividing the estimated amount of sand present on the beaches and in modern dunes by the estimated amount of sand deposited annually, and (2) measuring the annual erosion of an Illinois-Wisconsin shore line and dividing the results into the total wave-cut terrace.

RELATION OF DUNE TYPES TO PHASES

Dunes of the Glenwood phase are not conspicuous. In Lake County between Dyer and Schererville, they are rounded knolls that rise from 10 to 30 feet above the plain and, except for the regularity of the ancient beach, look like the hill and swale country of the moraines against which they lie. In LaPorte County and eastern Porter County, the dunes form a belt of low, elongate sand hills about a quarter of a mile wide (Pl. 1).

Dunes of the Calumet phase form a ridge of low, complex hills from the Michigan border southwestward to Salt Creek in

Porter County. West of Salt Creek in western Porter County, the dunes are elongate north-south, as high as 50 feet above the plain, and in a belt over 1 mile wide. Strong winds from the north during the Calumet phase may have aided in giving them their ridge-like longitudinal character. In eastern Lake County, the dunes are in a definite belt but rise only 10 to 30 feet above the plain. In western Lake County, low sand ridges fan out to mark the position of former bars and spits in the vicinity of Griffith (Pl. 1). The main Calumet beach forms a conspicuous sand ridge 2 miles north of Griffith. The sand hills of the beach stand from 20 to 30 feet above the plain.

Tolleston dunes are prominent northeastward from Gary, and some of them scarcely can be distinguished from modern dunes. They are overrun by modern dunes from the vicinity of Burns Ditch (Pl. 1), through Indiana Dunes State Park (Pl. 3, A), and northeastward into LaPorte County. In western Porter County and eastern Lake County (Pl. 3, B), the Tolleston dunes are high and are connected by low, winding ridges of sand. These lower connecting ridges trend northeastward-southwestward and may have been formed by retreating beaches of early Tolleston time. The north edges of the dunes appear to be truncated, perhaps by high water of the Nipissing phase. Commercial operation is feasible in Tolleston dunes east of Gary. West of Gary in the lower sand ridges small trucking operations may be successful (Pl. 5, B).

The modern high dunes associated with the shore of Lake Michigan from Gary eastward to the Michigan line are a composite of foredunes, blow-outs and resulting parabolic dunes, and lower connecting dunes (Pl. 3, A). The belt is nearly 1 mile wide in the northeastern part of Gary and narrows gradually to about half a mile at the Michigan line. The sand in some of the dunes farthest from shore actually may be as old as Nipissing, and many of the younger ones may have been formed from reworked Nipissing dunes. Vegetation has stabilized most of the dunes. Where man has disturbed the vegetable cover, sand movement takes place. Eroding shore lines, forest fires, insect infestation, earthquakes, and other phenomena of nature also may bare a dune. For example, workmen reported that an area cleared of sand 1 mile southwest of Michigan City along a part of the coast undergoing active erosion was covered by newly blown sand dunes in the past 30 years (Pl. 4, A). In one of the dunes the horizontal breadth

added to the dune in the last 30 years was found to be 150 feet. Thus the horizontal movement of the dune was approximately 5 feet a year.

COMMERCIAL SAND DEPOSITS

PHYSICAL ANALYSIS OF THE SANDS

Sampling.—Sampling of sandbanks is best accomplished along an active wall. Seldom can the lower 5 to 10 feet of sand-in-place be sampled because of loose sand in the pit, which is formed as the sand is excavated. Care should be taken to study cross beds before a location for sampling is selected. In sampling upward on a sandbank with cross beds dipping toward the sampler, one could move up along the angle of repose 50 feet and sample only one bed. It is satisfactory, however, to sample across the cross beds dipping away from the sampler. A high part of the wall usually will give the fairest sample. A recent slide makes a good place to ascend the bank if the edge of the slide has sheared away from sand-in-place. Thus by moving upward along the edge of the recent slide, the sampler can clear a face exposing sand-in-place.

The following method is useful in sampling northwestern Indiana sands. After a representative location has been selected, the bottommost sand-in-place is marked. On exposed faces less than 40 feet in height, a shovel of sand through each vertical foot is collected in pails and carried to the sampling cloth. Sampling begins at the base to avoid slides and contamination of the sample. On nearly vertical faces of 40 feet or more, after the sampler has cleared the side of the bank, the shovel is filled by biting into the sand continuously through 3 to 6 feet vertically. The sampling channel is carried upward as far as may be safe, to the top if possible. Careful notation is made of any breaks in the wall, such as weathering may provide, and additional samples may be taken at such an horizon. The dune sands, however, are more or less homogeneous, and one sample usually will suffice. The sand is thoroughly mixed on the sampling cloth, quartered, and samples taken from opposite quarters. The final sample may range from 3 to 5 pounds or more in size. Because the sand is wet, the sample should be kept in a canvas bag lined with one or two paper bags.

As the sand at and near the surface of a steep slope becomes dry, the grains roll down the slope and form a wedge of loose, secondarily-deposited material at the base. Sampling of this "talus"

obtains only the sands from the higher part of the dune, which are likely to be finer grained than those in the lower part of the dune. Because dry weather increases the depth of "talus," a good time for sampling is after a recent rain. It is convenient to use the top of a rail of the spur into the pit or any other similar point of relative permanence as a datum in the determination of dune thickness, vertical thickness sampled, and thickness not sampled for record.

As sand from the dune is removed, the wall of the sandbank recedes and the upper fine material slides into the sand below. Thus, sampling of the upper 10 or 15 feet of the dune is most difficult and dangerous because only silty soil and vegetation hold the sandbank as a sheer wall which is likely to slide. If the highest part of the section cannot be reached by the sampler, the sand sample which he does obtain will be slightly coarser than a truly representative sample.

Workmen report that if a slide occurs during the sampling, the sampler should move upward and keep on his feet. If he goes down slope, he is likely to fall and be engulfed.

Methods of analysis.—A quantitative analysis of some of the samples collected in the field was made in the laboratory. Petrographic studies of the sands were not attempted.

The samples were air-dried in the laboratory before any analyses were attempted. When they were thoroughly dried, a Jones Sample Splitter was used to mix the unsized field sample and, after mixing, to split the laboratory sample into two parts, one for immediate sieve analysis and density separation, and the other for chemical analysis and possible microscopic investigation.

Approximately 100 grams of sand were sieved for 30 minutes in a Ro-Tap shaker. The sand retained on each sieve used was weighed, bottled, and labeled.

In the process of density separation, each of the sieve sizes was handled separately. Each size was placed in a standard quantity of tetrabromoethane, which has a density of 2.95 to 2.96, and revolved in a centrifuge at approximately 1,600 revolutions per minute for 20 minutes. When the heavy and light mineral grains had separated, they were filtered, washed with methyl alcohol, and dried. Each of the two density parts then was weighed.

Each size in the sample was recorded as a weight percentage of the total weight of the unsized sample. After density separa-

tion, the light and heavy mineral portions were expressed as weight percentages of the total weight of each sieve size.

The greatest source of error resulted from weight loss in the finer fractions. Undoubtedly some of these finer particles adhered to the filter paper and were not recovered.

The analysis of the field samples was done in the sand and gravel laboratory of the Geological Survey by Andrew Hreha and Harold Sorgenfrei, under the direction of B. Dale Kline. The discussion of the methods used is from an unpublished report of the activities of the laboratory, which was prepared by Mr. Kline.

Analyses.—The following physical analyses were made by the sand and gravel laboratory of the Geological Survey.

Analysis of sample no. B5037 from modern beach in Porter County, NW1/4 NE1/4 sec. 36, T. 38 N., R. 5 W. Dark heavy minerals freshly deposited on present beach.

	Sieve analysis		Density separation ($C_2H_2Br_4$::D. 2.95±)		
Mesh size	Percentage of total sand	Particle shape[1]	Percentage of light minerals	Percentage of heavy minerals	Percentage of weight lost in analysis
.....	....	....	....	....	....
+ 28	.14	R	86.80	13.20	....
+ 48	4.98	SR-R	97.33	2.67	....
+ 80	15.06	R	85.25	14.75	....
+100	16.36	R	5.13	94.86	0.01
+200	62.94	R	.15	99.85	....
—200	.52	R	2.36	97.38	0.26

[1] R—Round
SR—Subround

Analysis of sample no. B5025 from modern foredune, Lake Michigan shore, north of Warren Street and Lake Shore Drive, northeastern part of Gary, Lake County, NW1/4NE1/4 sec. 33, T. 37 N., R. 7 W.

	Sieve analysis		Density separation ($C_2H_2Br_4$::D. 2.95±)		
Mesh size	Percentage of total sand	Particle shape[1]	Percentage of light minerals	Percentage of heavy minerals	Percentage of weight lost in analysis
.....	....	....	....	....	....
+ 28	2.30	R	94.60	5.30	0.10
+ 48	83.67	SR	98.92	1.03	0.05
+ 80	9.07	SR	97.50	2.10	0.20
+100	3.02	SR	89.30	10.60	0.10
+200	1.67	SR	55.20	44.70	0.10
—200	0.27	SR	86.97	11.03	2.00

[1] R—Round
SR—Subround

Analysis of sample no. B5033 of modern dune sand from Producers Core Sand Corporation, LaPorte County, SW1/4NW1/4 sec. 22, T. 38 N., R. 4 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Percentage of light minerals	Density separation ($C_2H_2Br_4$::D. 2.95±) Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	.45	R	98.25	1.75	....
+ 48	21.57	SR-R	99.41	.55	0.04
+ 80	69.78	SR-R	99.35	.58	0.07
+100	7.14	SR	96.90	3.06	0.04
+200	.41	SR	87.37	12.59	0.04
—200	.65	SR	66.52	32.47	1.01

[1] R—Round
SR—Subround

Analysis of sample no. B5027 of sand from the older part of a modern dune at Producers Core Sand Corporation, LaPorte County, SE1/4SE1/4 sec. 30, T. 38 N., R. 4 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Percentage of light minerals	Density separation ($C_2H_2Br_4$::D. 2.95±) Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	.58	R	98.23	1.77	....
+ 48	50.21	SR-R	99.60	.31	0.09
+ 80	45.64	SR-R	99.27	.71	0.02
+100	2.70	SR	95.53	4.43	0.04
+200	.93	SR	59.01	40.98	0.01
—200	.03	SR	79.97	16.23	3.80

[1] R—Round
SR—Subround

Analysis of sample no. B5020 from post-Tolleston dune sand at the Aetna-Superior Sand Company pit, northeastern part of Gary, Lake County, NE1/4 SE1/4 sec. 33, T. 37 N., R. 7 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Percentage of light minerals	Density separation ($C_2H_2Br_4$::D. 2.95±) Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	1.48	SR	98.23	1.71	0.06
+ 48	85.94	SR	99.08	0.74	0.28
+ 80	10.47	SR	96.60	3.31	0.09
+100	1.39	SR-R	93.29	6.66	0.05
+200	0.59	SR	58.84	41.14	0.02
—200	0.12	SR	85.11	11.88	3.01

[1] R—Round
SR—Subround

Analysis of sample no. B5022 from Tolleston beach sand at the Bos Sand Company, Porter County, NW1/4NE1/4 sec. 3, T. 36 N., R. 7 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Density separation ($C_2H_2Br_4$::D. 2.95±): Percentage of light minerals	Density separation: Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	0.68	R	98.37	1.49	0.14
+ 48	90.38	SR	99.09	0.68	0.23
+ 80	7.54	SR	99.69	0.25	0.06
+100	1.08	SR	97.50	1.87	0.63
+200	0.29	SR	79.10	20.60	0.30
—200	0.02	SA-SR	89.90	6.44	3.70

[1] R—Round
SR—Subround
SA—Subangular

Analysis of sample no. B5024 from Calumet beach sand, 1 mile northeast of Crisman, Porter County, NW1/4SW1/4SE1/4 sec. 31, T. 37 N., R. 6 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Density separation ($C_2H_2Br_4$::D. 2.95±): Percentage of light minerals	Density separation: Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	0.56	R	98.81	1.14	0.05
+ 48	91.51	SR-R	98.41	1.35	0.24
+ 80	6.95	R	97.08	2.57	0.32
+100	0.57	SR	92.80	6.99	0.21
+200	0.27	SR	88.70	10.21	1.09
—200	0.14	SR	92.45	4.55	3.00

[1] R—Round
SR—Subround

Analysis of sample no. B5031 from Calumet beach sand at the Crisman Sand Company pit, half a mile northeast of Crisman, Porter County, NE1/4SE1/4 sec. 1, T. 36 N., R. 7 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Density separation ($C_2H_2Br_4$::D. 2.95±): Percentage of light minerals	Density separation: Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	2.51	R	97.98	1.82	1.20
+ 48	87.02	SR-R	97.53	2.29	0.18
+ 80	7.48	R	94.24	5.58	0.18
+100	1.15	SR	85.09	14.73	0.19
+200	1.15	SR	87.18	12.73	0.09
—200	0.69	SR	93.50	4.10	2.40

[1] R—Round
SR—Subround

Analysis of sample no. B5021 from Glenwood beach sand, 2 miles east of Dyer, Lake County, NW1/4NW1/4 sec. 16, T. 35 N., R. 9 W.

Mesh size	Sieve analysis: Percentage of total sand	Particle shape[1]	Density separation ($C_2H_2Br_4$::D. 2.95±): Percentage of light minerals	Density separation ($C_2H_2Br_4$::D. 2.95±): Percentage of heavy minerals	Percentage of weight lost in analysis
......	....	....	....	....	....
+ 28	0.21	R	99.60	0.30	0.10
+ 48	53.56	SR	98.80	0.54	0.66
+ 80	34.98	SR	98.90	0.80	0.30
+ 100	4.94	SR	98.90	0.80	0.30
+ 200	5.79	SR	97.57	2.31	0.12
—200	0.52	SR	85.90	10.77	3.33

[1] R—Round
SR—Subround

COMPOSITION OF THE SANDS

Mineralogy.—Cressey (1928, pp. 31-32) stated that in most of the beach and dune sands, quartz grains constitute more than 90 percent of the sample. Other lightweight minerals are principally feldspars. In a petrographic study of beach sands of the southern part of Lake Michigan, Pettijohn (1931, p. 438) included four samples from Indiana beaches, namely, Miller Beach, Baileytown Beach, Waverly Beach, and Washintgon Park (Michigan City). The percentage by weight of all heavy minerals (those with a specific gravity of more than 2.95) was 0.5, 0.9, 1.1, and 0.7 respectively for the four samples. The percentage by number of grains for each of the heavy minerals is summarized in the following table:

Percentage by number of grains of heavy minerals of four samples of beach sands

Mineral	Location of sample: Miller Beach (NE Gary)	Baileytown Beach (Porter Co.)	Waverly Beach (Indiana Dunes State Park)	Washington Park (Michigan City)
Hornblende	31.2	18.4	14.7	18.4
Ilmenite and Magnetite	10.3	16.2	26.6	25.3
Epidote	5.3	2.5	3.3	2.2
Garnet	3.6	7.2	14.4	10.1
Hypersthene	2.0	1.6	0.7	2.6
Augite	1.7	1.6	1.9	3.0
Diopside	1.4	0.6	1.9	1.4
Zircon	1.4	1.0	0.7	1.4
Tourmaline	0.8	0.6	0.5	1.6
Actinolite	0.7	0.8	0.9	0.8
Titanite	....	....	....	0.8
Staurolite	0.6	....	....	....
Leucoxene and other altered grains	40.3	49.5	32.4	31.0

As the dune sand is blown from the beaches, the samples in the wind-blown deposits presumably will not vary greatly from the beach samples. In wind selection of grains, however, the heavy mineral content of dunes can be expected to be slightly less than that of beach deposits. In addition, of the heavy minerals, the lighter weight amphibole and pyroxene, and perhaps epidote, can be expected to predominate over such minerals as garnet, ilmenite, and magnetite. Carbonate minerals amount to little more than a trace at the southern end of Lake Michigan, for the Indiana sands represent the end product of the longshore currents on both sides of the lake.

Chemical analysis.—The following analysis of the Michigan City sands was given by Logan (1922, p. 1051):

Analysis of Michigan City sands

	Percentage
SiO_2	91.98
Al_2O_3	4.44
Fe_2O_3	.56
CaO	2.20

Chemical constituents were determined for eight of the nine samples that were subjected to sieve tests and density separations. The chemical analyses were made in the spectrographic and chemical laboratories of the Geological Survey and are given in the following table.

Constituents of eight samples of dune sands[1]

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	TiO_2	ZrO_2
B5025	91.5	3.8	.64	.46	1.6	.31	.089	.0047
B5033	91.9	3.8	.53	.41	1.4	.38	.085	.0073
B5027	91.9	4.4	.59	.22	0.6	.31	.10	.0047
B5020	88.7	4.8	.76	.59	2.0	.43	.13	.0094
B5022	91.4	4.7	.50	.26	0.8	.38	.071	.0032
B5024	92.3	4.4	.72	.24	0.5	.35	.13	.0040
B5031	86.7	5.0	1.40	.79	3.0	.32	.28	.0068
B5021	89.7	6.2	.82	.21	0.6	.55	.20	.0079

[1] All constituents except silica were determined spectrographically by R. K. Leininger. Silica determinations were made chemically by Maynard E. Coller.

DETAILS OF DUNES OBSERVED IN COMMERCIAL OPERATIONS

Relationship of grain size to texture of dunes.—The lake sands associated with beaches and dunes of northwestern Indiana have an A. F. S. grain fineness of 45 to 70.[2] In the field, grain size can be estimated rather accurately by the experienced observer. Men who work with dune sands dig into the bank to find sand-in-place. This is likely to be near the top of the bank above the thick "talus." The men take the wet sand in the hand and rub it between the thumb and the forefinger. Dry sand will not serve in making this crude test. Wet sands of known fineness number should be used for practice.

In general, dune sands are coarser near the beach and become finer with increasing distance away from the lake. Sand in the base of a dune generally is slightly coarser than that at the top. The mantle of the dune may be silty. Progressive variation in grain size in a cross section of a dune may change, for an older dune may be covered by younger sand in what appears to be the same dune (Pl. 4, A). Sand on top, therefore, may run from fine to coarse downward, and a silty zone, dipping at any angle from 0 to 35 degrees, may be encountered far below the surface, where the top of the older dune is encountered. Thus a coarse sand may be taken from the upper part and from the bottom, a fine sand from just below the old soil zone, and a mixed sand from the "talus." Three grades of sand may then be obtained from the same operation. Evidence of buried dune lines was noted only within the younger dune belt.

Each dune has an average grain size differing from that of adjacent dunes. If extensive commercial operations are anticipated, the operators should sample each dune by boring. The common practice is to remove one dune at a time. On the average, sands are finest in the western part of the area and become coarser eastward in the direction of Michigan City. An A. F. S. grain fineness number of 60 to 65 is common in Lake County, whereas 50 to 55 is the average near Michigan City. This progressively increasing coarseness northeastward probably is related to the parent materials in the glacial till on the east shore of Lake Michigan and to the longshore currents which carry this material southward. Deposition of the finest sand might be expected on the

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[2] Methods of determining the fineness number are given by the American Foundrymen's Society (1952, pp. 29-59).

shores in Lake and Porter Counties because they are located at the head of the lake.

A sieve analysis of dune sand from a small pit used by the Weil-McLain Company, Michigan City, shows that the sand there has an A. F. S. grain fineness number of 51. This number is found by multiplying the percentages of a 50-gram sample retained on a series of sieves by a group of multipliers and then by dividing the total produce by the total percentage retained on the sieves. The sieve sizes, multipliers, and calculations used are given in the following table and by the American Foundrymen's Society (1952, p. 40).

Analysis of dune sand from a Weil-McLain Company pit

U. S. series equivalent number	Percentage of 50-gram sample retained on sieve	Multiplier	Product
6	0.0	3	0.
12	0.0	5	0.
20	0.3	10	3.
30	1.4	20	28.
40	4.7	30	141.
50	21.8	40	872.
70	49.1	50	2455.
100	21.8	70	1526.
140	0.9	100	90.
200	0.1	140	14.
270	0.0	200	0.
Pan	0.0	300	0.
Total	100.1		5129.

$$\text{A. F. S. grain fineness number} = \frac{\text{Total produce}}{\text{Total of percentages retained on sieve}} = \frac{5129}{100.1} = 51$$

Roundness.—Most of the sand grains are subround. A few scattered round and frosted grains are present, mostly in the larger sizes. Many of the fine dark mineral grains are subround to round. Sphericity is not common.

Porosity.—The sands are porous and permeable. After half an inch to 1 inch of rainfall, dune sands on open surfaces are wetted to a depth that depends upon the slope. At the angle of repose, about 32 degrees, sand is wetted from 2 to 4 inches below the surface. In heavy rains, water is held in the intergrain spaces so tightly that limited run-off takes place. Clay content of the sands near the lake commonly is less than 3 percent.

Moisture.—Sands in the dune region of northwestern Indiana always are damp a few inches below the surface. Sands loaded

from a bank into open cars always are wet. Analysis of samples of wet sand from open railroad cars shows as much as 5 percent water by weight.

Dry sand is more desirable than wet sand for most commercial uses except fill. For example, in molding and core sands moisture must be carefully controlled. It is much simpler, and more exacting, to start the mix with a dry sand and add the moisture desired rather than to determine moisture content and then increase or decrease it.

Weathering.—The geologically older sands usually are deep buff in color, probably because iron has been leached from the dark minerals in the sand and because thin films of clay cling to the grains. Thin seams of clay may develop in the upper 15 feet of old dunes. Such clay seams are present in the sand associated with the Calumet beach at Crisman and Willow Creek (Pl. 1).

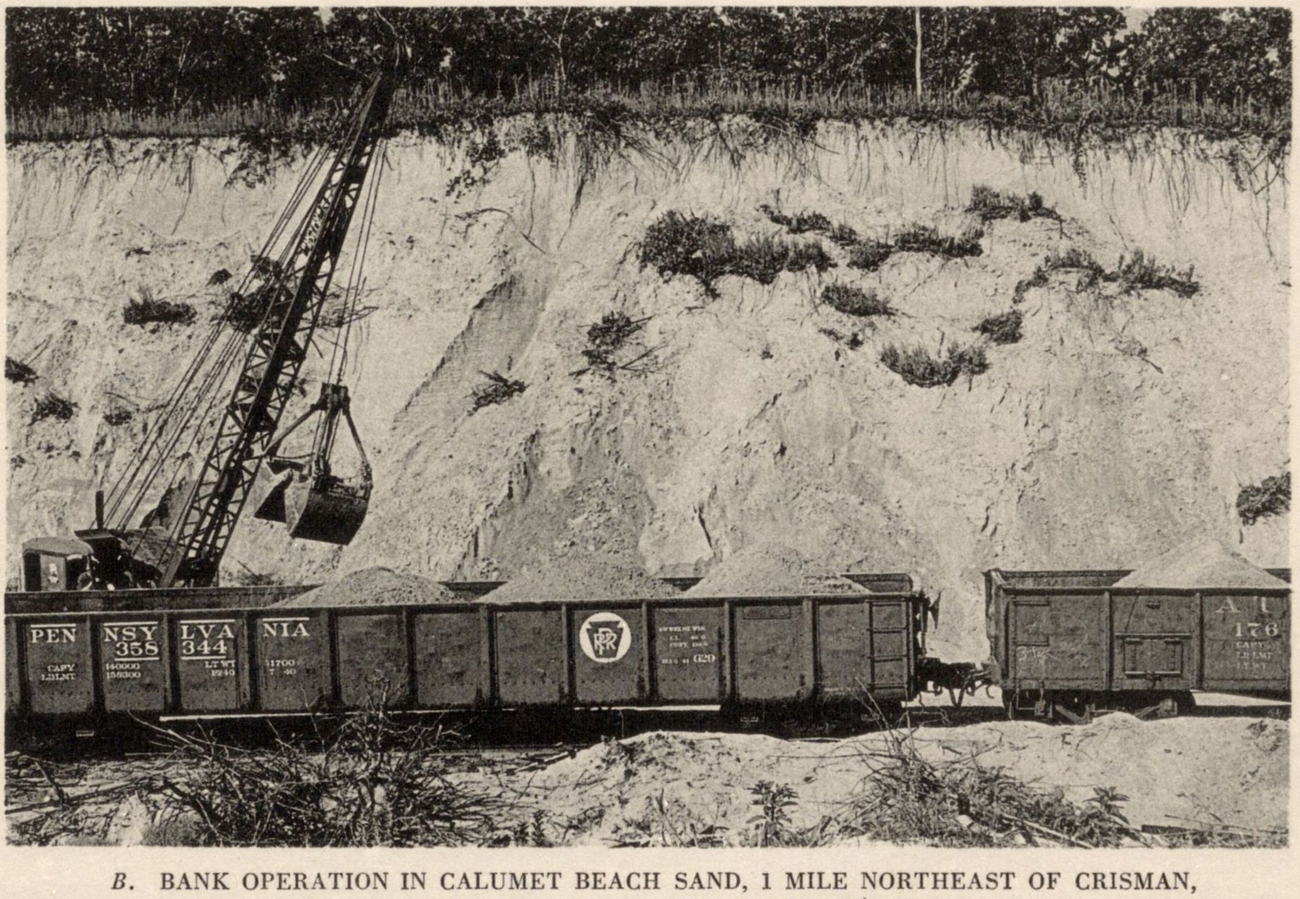
Calcium carbonate is leached from the mantle and concentrates along rootlets of dune grasses as lime "pipes." The "pipes" are almost white, loosely cemented, from a quarter to half an inch in diameter, and from 2 to 10 inches long. Such carbonate "pipes" increase in number toward the Michigan state line.

The weathered soil zones which developed on old dunes and which later were covered by younger sands are deeply stained with iron oxides for several feet below the old soil line. These old soil lines were observed only beneath modern dunes (Pl. 4, A).

Cross bedding.—Cross beds are the most conspicuous feature of the opened dune (Pl. 4, B). The working face exhibits a cross section. As the face is worked back, the cross beds change angles, or they may even reverse in dip. Dips may be as much as 35 degrees. Beds representing an old angle of repose of a buried dune are exposed in many places, but the angles tend to be a little lower, rather than higher, than those of present blowing sand. The fact that the individual layers vary in grain size accounts for separation into beds. The faces of dunes cut along the strike of the cross beds show pseudo-horizontal bedding. Most of the dips on the cross bedding are from 1 to 15 degrees and probably were formed on the windward side. On the average, dips of the angle of repose are south and east, a fact which indicates that the strongest winds came from the north and west during dune formation.

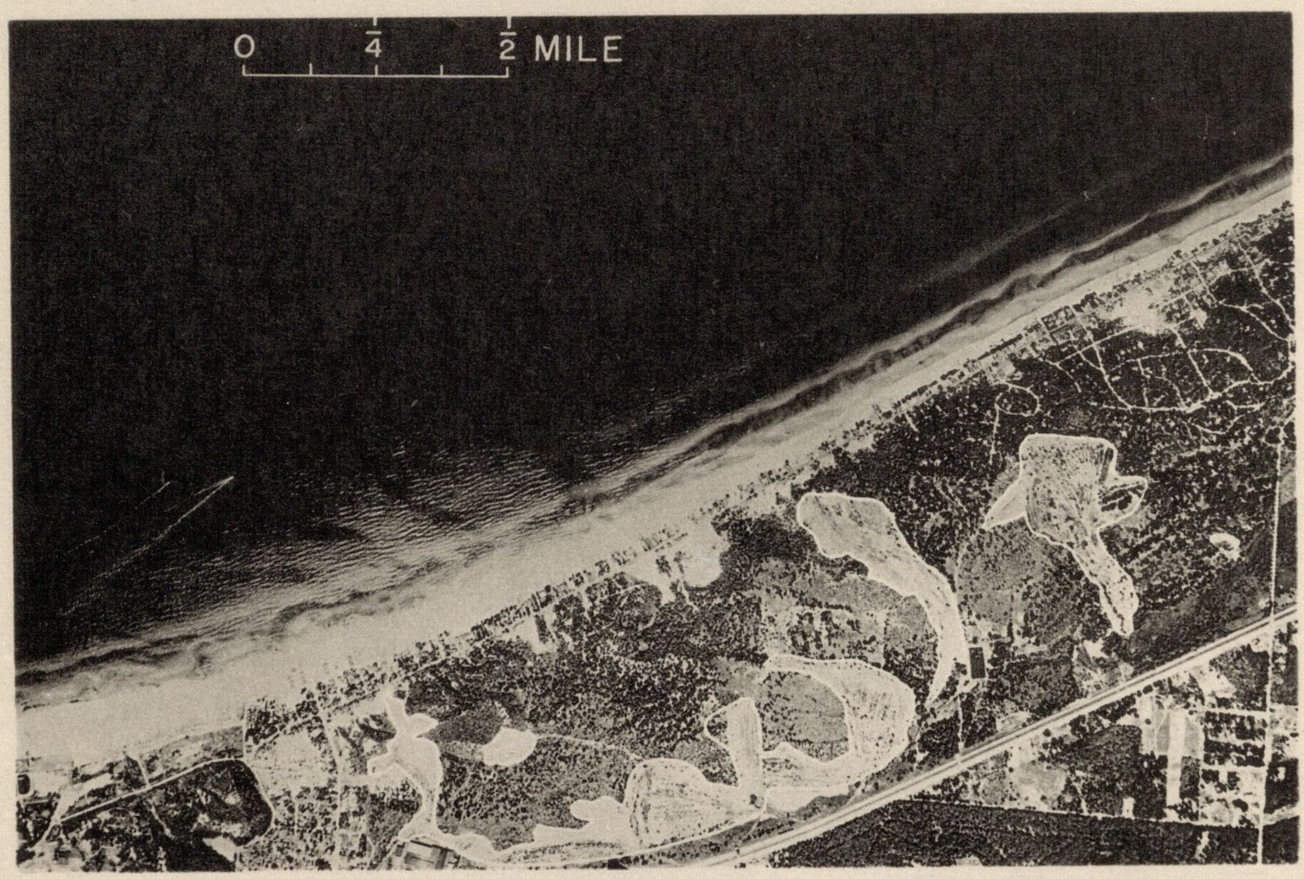
Beach "shingle."—Commercial operations in dunes that are built over old beach and strand lines may uncover beach pebbles.

A. DEPOSITION OF RECENT WIND-BLOWN SAND OVER AN OLDER DUNE, 1 MILE SOUTHWEST OF MICHIGAN CITY, SE¼ SE¼ SEC. 30, T. 38 N., R. 4 W., LAPORTE COUNTY. LAKE MICHIGAN IS TO THE LEFT OF PHOTOGRAPH.

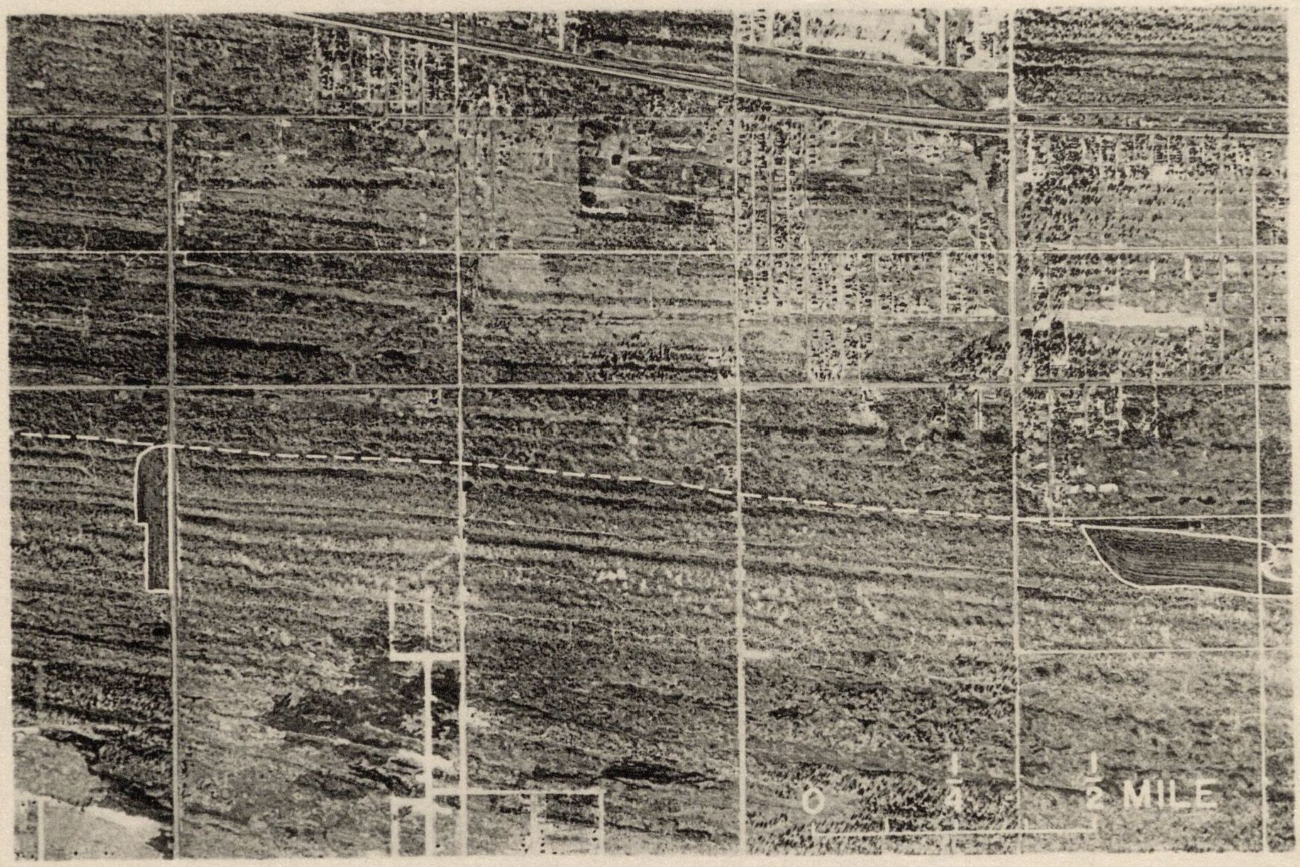


B. BANK OPERATION IN CALUMET BEACH SAND, 1 MILE NORTHEAST OF CRISMAN, SW¼NW¼ SEC. 6, T. 36 N., R. 6 W., PORTER COUNTY.

SAND PITS IN MODERN AND OLDER DUNES.



A. LARGE MINED-OUT AREAS OF SAND (OUTLINED) NEAR THE EAST LIMITS OF MICHIGAN CITY.



B. TRUCKING AREAS (OUTLINED) ALONG THE TOLLESTON BEACH (DASHED), WEST LIMITS OF GARY, LAKE COUNTY.

PATTERNS OF SAND REMOVAL.

The pebble line then will be the base of the operation. The beach "shingle" will be found near the level of the lake plain or a few feet below it.

Fly sand.—Fissile fragments of Devonian shale, 5 to 10 mm in diameter, are blown as much as a quarter of a mile from the beach. These fragments may form thin bands in the cross bedding of the younger sands. Traces of fly material are not particularly harmful in the sand, but a large quantity of such material would limit the use of the commercial sand.

Bonding.—Wet sands which contain a bond feel smooth to the touch, and when they are tossed about in the hand, they tend to "ball." Sand with bond in it will form a steeper bank than clean sand (Pl. 4, B). The term "bank sand" often is used to indicate the presence of a small percentage of bond. The bond line will show as a break in the profile of the bank if weather and the conditions of operation allow a profile to form. Bonds of clay and iron oxide are more common in the older beach sands, but in none of the operations was the bond estimated to exceed 5 percent of the total weight. In general, the weight of clay does not average more than 2 or 3 percent in the Tolleston and younger sands.

Color.—The sands generally range from near white to light buff. The older the sand, the deeper buff is its color. Oxidation of the iron in dark mineral grains, such as the amphiboles, pyroxenes, and ilmenite, accounts for the buff color. Leaching of the silty particles which are spread over the top surfaces of most dunes also provides some iron stain.

Buried objects.—According to reports, bones of prehistoric animals, deer antlers, and partial skeletons of Indians have been found in or near the bottom of dunes in commercial operations. An Indian artifact was reportedly found near the base of a dune at the Crisman Sand Company pit. Old tree trunks in upright positions are numerous along old soil lines buried by recent sands in the modern dune belt near the lake shore (Pl. 4, A). These old stumps and logs are removed by crane and buried in the trench at the foot of the bank, or are thrown on the spoil ridges (Pl. 6, A). The location of buried trees in a modern dune may be marked by vines which survive after the tree has been killed by sand burial. Wood was not observed in sand-in-place in Tolleston and older dunes.

Present additions to the sands.—Eventually, a considerable quantity of foreign material will be added to the dunes close to shore. Refuse from the steel and other industries situated on the shore of Lake Michigan is being scattered along the shore line by longshore currents. Fragments of materials associated with the steel industry, especially slag, are being added to the beach sands. Concentrations of heavy black mineral fragments are cast up on the shore during a period of strong winds and currents. A layer 1 inch thick was observed along the shore 2 miles southwest of Michigan City. These dark fragments seem too numerous to have come from the natural sands.

Sample no. B5037 (see table on p. 15) was taken from the concentration observed near Michigan City. Because this sample was unlike quartz sand in composition, it could not be compared with the spectrographic standards used for the other analyses and only its physical analysis is reported.

ECONOMIC UTILIZATION

COMMERCIAL USES AND NOTES ON REQUIREMENTS

Fill.—Sand makes an excellent fill because it settles quickly into place and remains stationary as long as it is protected from the action of flowing water or wind. Construction work can begin on a sand fill almost at once. Dune sand has been used in large quantities for the elevation of railroad tracks and roads in the Chicago area.

Mortar and plaster.—Dune sand is slightly finer grained and less "sharp" than the trade demands at present. Dune sand has been and is being used to a limited extent in the building trades. Those who have used dune sand aggregate for plasters and mortars have complained that this aggregate permits excessive cracks and that the product lacks strength. Research in this field might develop satisfactory methods of using dune sand for these purposes.

Paving.—A common use at present is in top dressing for asphalt paving. Dune sand mixed with petroleum products serves well for patching holes in this type of paving. The sand must be dried before it is mixed.

Core sand.—In foundries, Indiana dune sand is used widely for making cores. This sand is particularly suited for cores in large

castings and is being used for cores in the most exacting ferro-alloy castings. Smaller cores, however, require a finer grade of sand. For example, in producing cores for one type of casting, a foundry in Michigan City reported that 1 quart of an oil mix was used as a binder for approximately 70 quarts of dune sand. The formed core then was baked. In most foundries, the core is discarded after it is used in making one casting, because the burned surfaces that result from contact with the molten metal compact the sand. In addition, re-use of the sand in the cores disturbs oil mix control; therefore, it is more economical to use fresh dune sand. Discarded cores, although they carry an oil odor, make satisfactory fill material.

Molding sand.—Molding sands are variable in fineness and may or may not have natural bond. On the whole, dune sands are too coarse for many of the casting operations. Tennessee molding sand has long been used in foundries of the area because it withstands high temperature, is fine-grained, and contains from 10 to 20 percent by weight natural clay bond. If the bond is not sufficient for the particular casting, clay is added. If too much bond is present, clear sand is added. A different fineness of the sands is used for different types of castings. For larger ferrous castings a coarse sand, even dune sand of approximately A. F. S. grain fineness number 65, may serve. For smaller castings, which may be intricate, and for brass work a finer grained sand of 80 to 200 A. F. S. grain fineness may be required.

The following table gives examples of a few fine-grained molding sands and permits comparison of the Indiana dune sands with sands from other sources:

Comparative fineness of molding sands

Name or source of sand	A. F. S. grain fineness number
Custom ground (Ottawa, Illinois)	very fine silica sand
Bremen, Ohio	185
Sandusky, Ohio	126
Rockton, Illinois	125
Tennessee molding sand	120
Zanesville, Ohio	75
Tolleston beach sand (East Gary)	65 (approximate)
Calumet beach sand (Crisman Sand Company)	55 (approximate)
Modern dune sand (Manley Sand Company, Michigan City)	55 (approximate)

Each carload of molding sand must be sampled and analyzed. A typical physical analysis of a carload of Zanesville sand was

provided by William Freyer of the Weil-McLain Company, Michigan City. According to Mr. Freyer's analysis, the Zanesville sand showed a moisture content of 9 percent by weight; its green and dry compressive strength was 8.1 and 87.5 pounds per square inch respectively; its permeability number was 76; its A. F. S. fineness number, 75; and its A. F. S. clay content, 17.9 (a 15 to 18 average is common). These properties of sand and tests to determine them are given by the American Foundrymen's Society (1952, pp. 29-85). Mr. Freyer also gave the following examples of a molding sand mix: 8 parts dune sand of A. F. S. grain fineness number 53 to 55; 5 parts Sandusky sand of A. F. S. grain fineness number 90; 2 parts of seacoal (powdered coal of less than 3 percent ash); and 2 parts of "Grundite" (highly plastic clay, which probably is illite, from Grundy County, Illinois).

Synthetic molding sands, made by bonding a high silica sand with bentonite, are much used instead of naturally bonded sands. Because the dune sand is readily accessible and cheap, some of it may be mixed with the finer grained and more expensive molding sands when the type of casting will allow it. Molding sand can be used over and over again. One foundry in Michigan City, the Josam Manufacturing Company, reported that 1 ton of sand was added to the molding sand mix each week.

Engine sand.—A fairly sharp quartz sand which is free from clay and which is fine enough to lie on the rail is desired for engine sand. Sands of A. F. S. grain fineness number 50 to 65 fulfill this requirement and are furnished in quantity from dune sand. The sand must be dry in order to pour or run readily. Proximity to one of the great railroad centers of the world makes the use of dune sand economical for this purpose.

Fire and furnace sand.—A sand that has a high melting point, a high silica content, and a low content of calcium and other flux is required for lining the runners that carry melted iron from the blast furnaces to the ladles or ingot molds. In order to mold on the runners and yet retain porosity, a furnace sand must contain but a small percentage of bond. It must be free of phosphorous and sulphur so that it will not contaminate the molten metal. The sands associated with the Calumet beach near Crisman are especially fitted to fulfill these requirements (Pl. 4, B). Small quantities of dune sand are used in mixes for patching cupola linings in foundry furnaces.

Minor uses.—Quantities of dune sand are used for bottle glass, abrasives, sand blast, filter, pulverized silica, sand beds for laying brick, and other purposes. Formerly, the manufacture of sand-lime brick constituted a considerable industry in the Michigan City area.

PRODUCTION

Use of machines.—In order to produce dune sand at competitive prices, the operator must handle the sand by machine and in quantity. It is well for a company to be large enough to operate more than one pit so that several sizes of sand can be produced for an expanding market. Because sand is both bulky and heavy, shipping by rail has been most efficient for the general trade. Thus the large operations are situated within 1 mile of rail transport so that spur lines may be run to the pits. One crew, a craneman and two helpers, can load from 10 to 15 cars in an 8-hour day. A Diesel Caterpillar crane which has a 1¼-cubic yard "clam" bucket is widely used. The bank of sand should be long enough so that a crane can move freely along the bank and load a string of stationary cars (Pl. 6, A). If the bank is short, a double track of cars may be required. A double track, however, requires track moving, presents curve problems, and may result in an inconvenient and cramped working environment.

Locomotive cranes are used by some operators. This type of crane requires an extra track. The sandbank is not stripped. The spoil, which consists mostly of trees and stumps, is buried in the pit as the sand is removed below the level of the track, or it is thrown over the far side of the cars as spoil ridges (Pl. 6, A). The bank sand is loaded into open gondola cars. Equipment must be kept in good condition so that cars can be loaded, moved from the pit, and empty cars brought in each day. Helpers must clean cars and seal them with paper and burlap in advance so that the craneman can work steadily. Sand is removed to the subsurface water level, to clay, to pebbles, or if none of these hindrances appears higher, to about 10 feet below the level of the track.

Size of dune.—Minimum height of the working bank in the dunes at present is about 25 feet, and the maximum is nearly 100 feet. The working distance along a sandbank is generally from 400 to 600 feet. The railroad spurs range from a quarter of a mile to 1 mile in length (Pl. 5, A). Less than 1 percent of the sand is re-

moved by trucks, although this type of hauling is becoming more common in Lake County (Pl. 5, B). Present operations extend primarily north-south or east-west, but old spoil ridges indicate that the spurs fanned from the junction with the main line (Pl. 5, A).

Sand drying.—A more expensive type of operation furnishes dry and clean sand which is generally in heavier demand during freezing weather, and at all times for use in foundries. (Wet, frozen chunks of sand are loaded and unloaded with great difficulty in the winter months.) This operation strips the sand dune of tree growth and brings sand to the oil-fired drier by slack line cable and conveyor (Pl. 6, B). Wood and dust are burned, the ash blown out, and the sand screened in the process. By means of a mechanical loader and spreader which distributes it evenly throughout, the finished sand is put into box cars which have been sealed carefully with paper. Dried sand is stored in bins or silos when empty box cars are not available to ensure continuous operation.

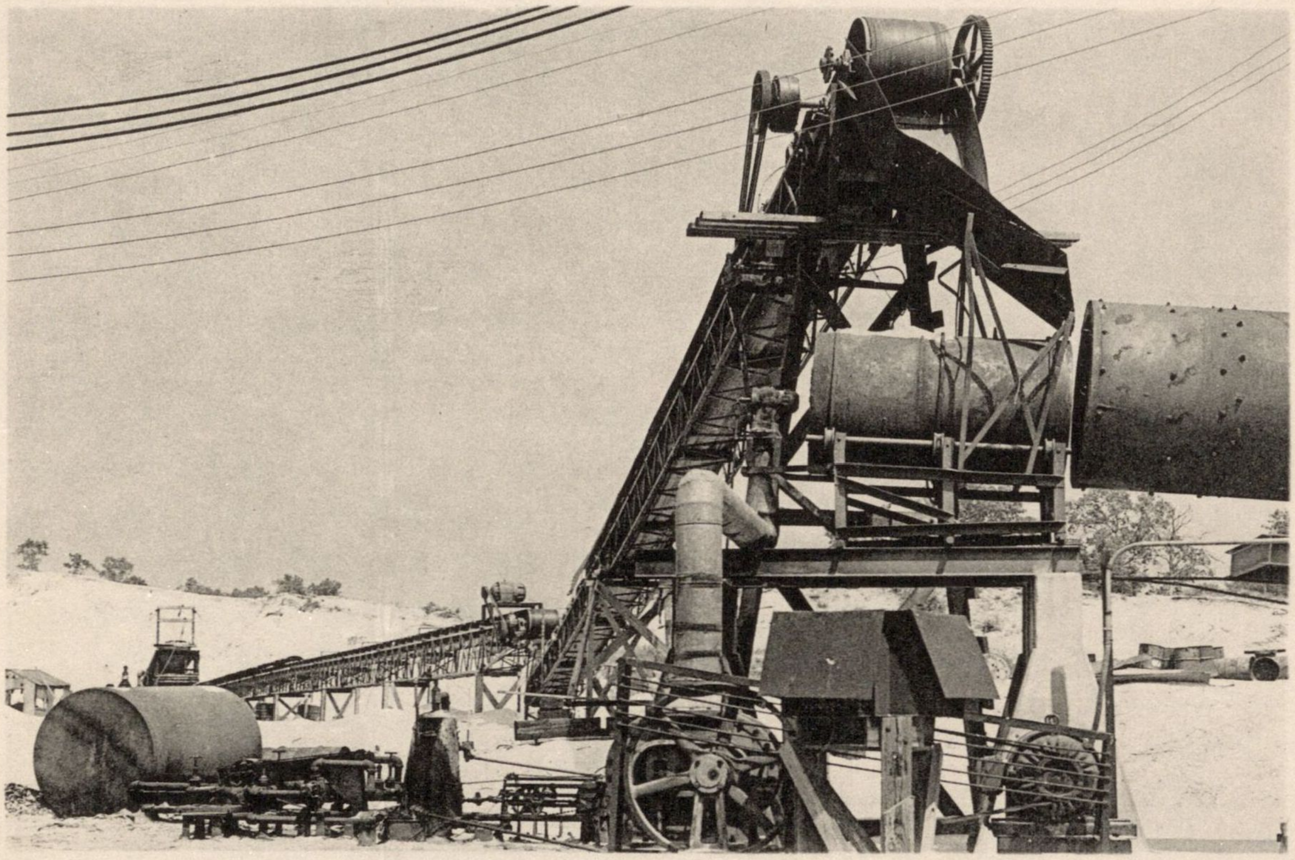
Prices.—The greatest part of bank sand sold, in August 1950, for 40 to 70 cents per ton loaded in cars. The buyer processes the sand as he chooses. Sand which had been dried, screened, and cleaned at the point of loading commanded a premium price of about $2.50 per ton. The greatest cost to the distributor and/or consumer was the cost of transportation. For example, some molding sands from New York or New Jersey cost as much as $5.00 to $6.00 per ton delivered to the Chicago area. Prices fluctuate with demand and with the value of the dollar.

PROBLEMS OF PRODUCTION

Weather.—Cold and freezing weather offers the greatest problems in production. Snow and freezing water on the bank may temporarily halt operations. In such weather railroad cars are difficult to clean, and dump cars may be hard to open or to close tightly. Summer heat slows the laborers in the car cleaning process, so that car cleaning and loading is done in the morning as much as possible in order to avoid the heat of the early afternoon.

Operating space.—When the space between the bank and the spur becomes too broad for the crane to reach the cars, the track is "pulled over" by a crane or a bulldozer. This work requires time because the track must be laid so that it will not spread under the weight of loaded car.

A. SPOIL RIDGES (TO THE LEFT) AND REMOVAL OF LARGE DUNE, NW¼NE¼ SEC. 3, T. 36 N., R. 7 W., WESTERN PORTER COUNTY.



B. SLACK LINE CABLEWAY, CONVEYOR BELT SYSTEM, AND PART OF DRYING EQUIPMENT, MANLEY SAND COMPANY, DUNE PARK, PORTER COUNTY.

MODERN SAND OPERATIONS.

LAND USE

After the sands have been removed, the property may be prepared for subdividing rather simply with a moderate amount of work by bulldozers. Because most sandbank operations are in the metropolitan area, the sale of the worked-over property brings very fair returns to the owners. The large operators or corporations who can afford to hold unproductive land for some years can take off the sand as needed and eventually gain profit from the land. Leasing is common, although the largest operators have foreseen future needs and have bought up tracts for reserve.

Before one leases or buys property for sand, the dune or dunes should be bored and sampled to determine grain size and composition. Each dune differs slightly from others in grain size, which may be enough to change the economics of the proposed operation, because the sand consumer's demands are increasingly exacting.

CONSERVATION

Some natural dunes need to be preserved, as is being done at Indiana Dunes State Park. Residential areas, such as the northeastern part of Gary, Ogden Dunes, Dune Acres, Beverly Shores, and Long Beach, will conserve the natural dune topography to some extent. However, because of the many problems of building on sand dunes, the average householder probably will be better satisfied to live on the more level ground of the worked-out sand areas (Pl. 1). The sand should be used, not wasted, as the market calls for it. After the sand has been removed, spoil ridges should be leveled and subdivisions plotted. If subdivision is planned, stumps and trees should not be buried in the trenches. Considerable new and reworked sand will come constantly to the shore lines. The quantity may be great enough to be of commercial value. Increased use of dredges (locally called "sand suckers") may interfere with the natural accumulation of sand along the shore.

RESERVES

About 5,000 tons of dune sand are taken from the area each day. In the past 70 years large tracts once comprising some of the most spectacular and picturesque dunes already have been cleared of sand (Pl. 1). The encroaching metropolitan districts are rapidly breaking the dune land into small tracts and subdivisions. Thus

reserves of available sand have decreased rapidly until today but few large holdings are available (Pl. 1).

Various estimates can be made of the reserves presently available to the sand industry. It seems reasonable to suppose that if conditions and demand stay about as they are and that if removal of sand continues at the present rate, the large commercial sand operations can continue for a period of 50 to 100 years in northwestern Indiana.

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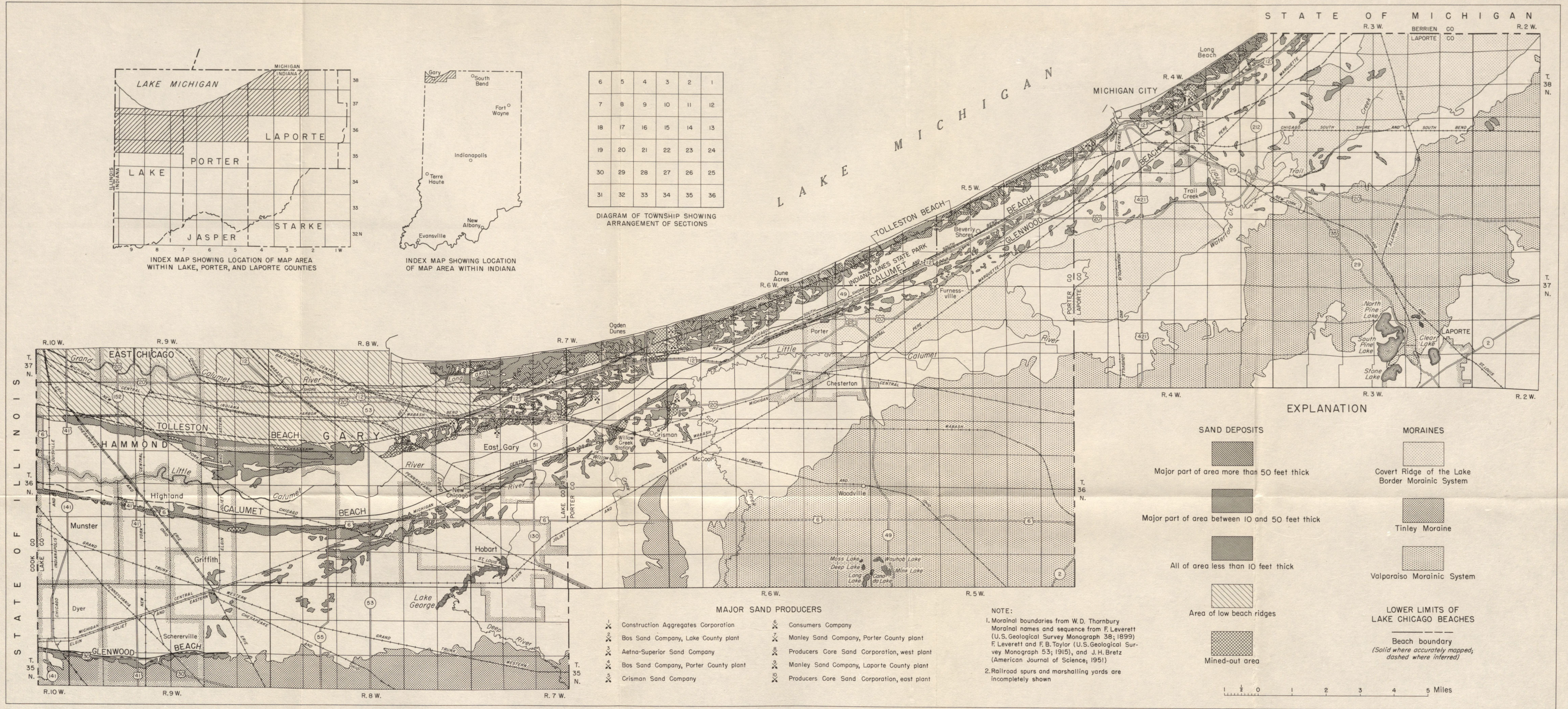

Base from General Highway and Transportation maps, scale 1:63,360, corrected to January 1, 1937. Section lines, highways, railroads, lakes, and streams revised from aerial photographs

INDUSTRIAL SAND DEPOSITS SOUTH OF LAKE MICHIGAN

Geology by C. L. Bieber, assisted by N. M. Smith
August 1950